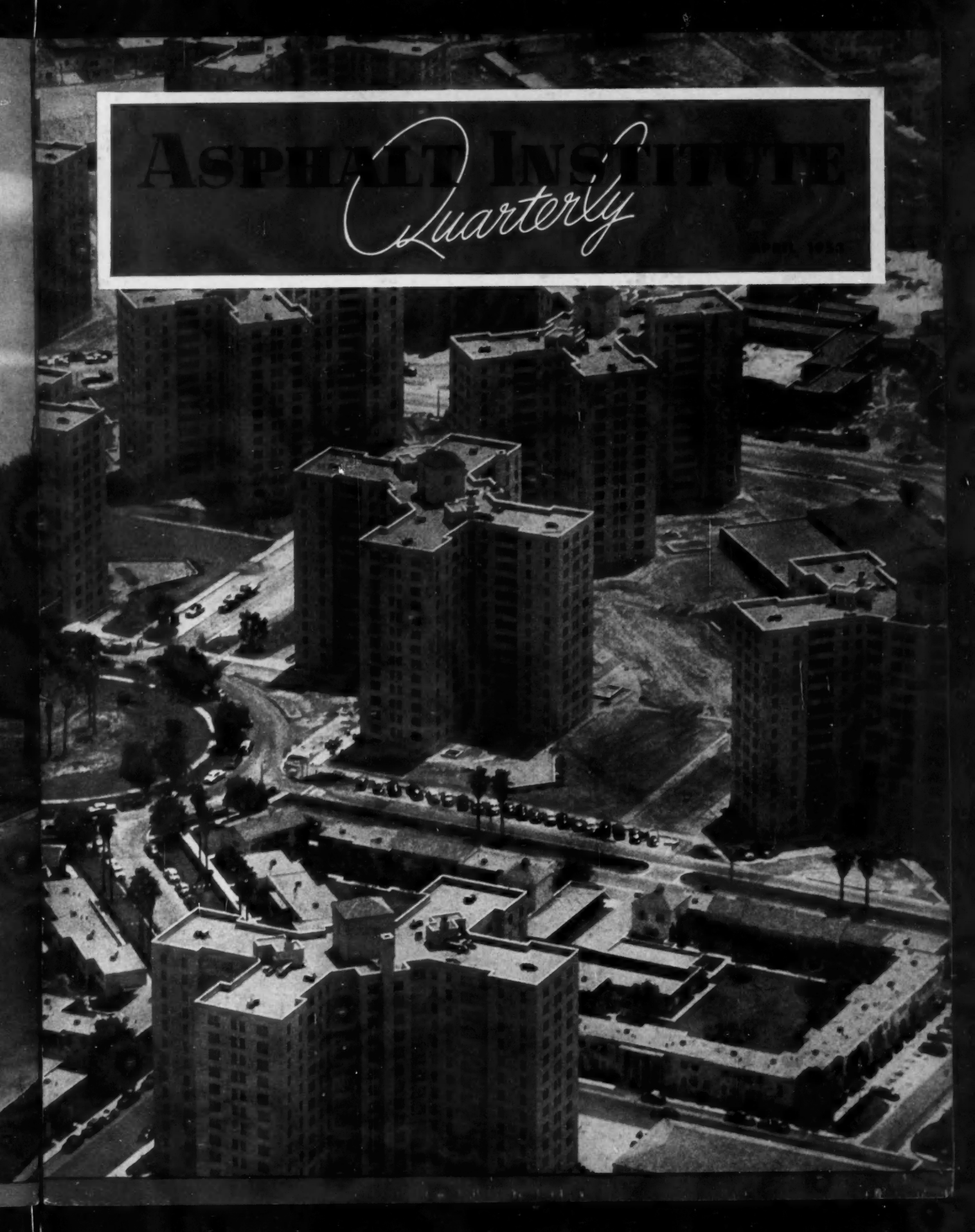
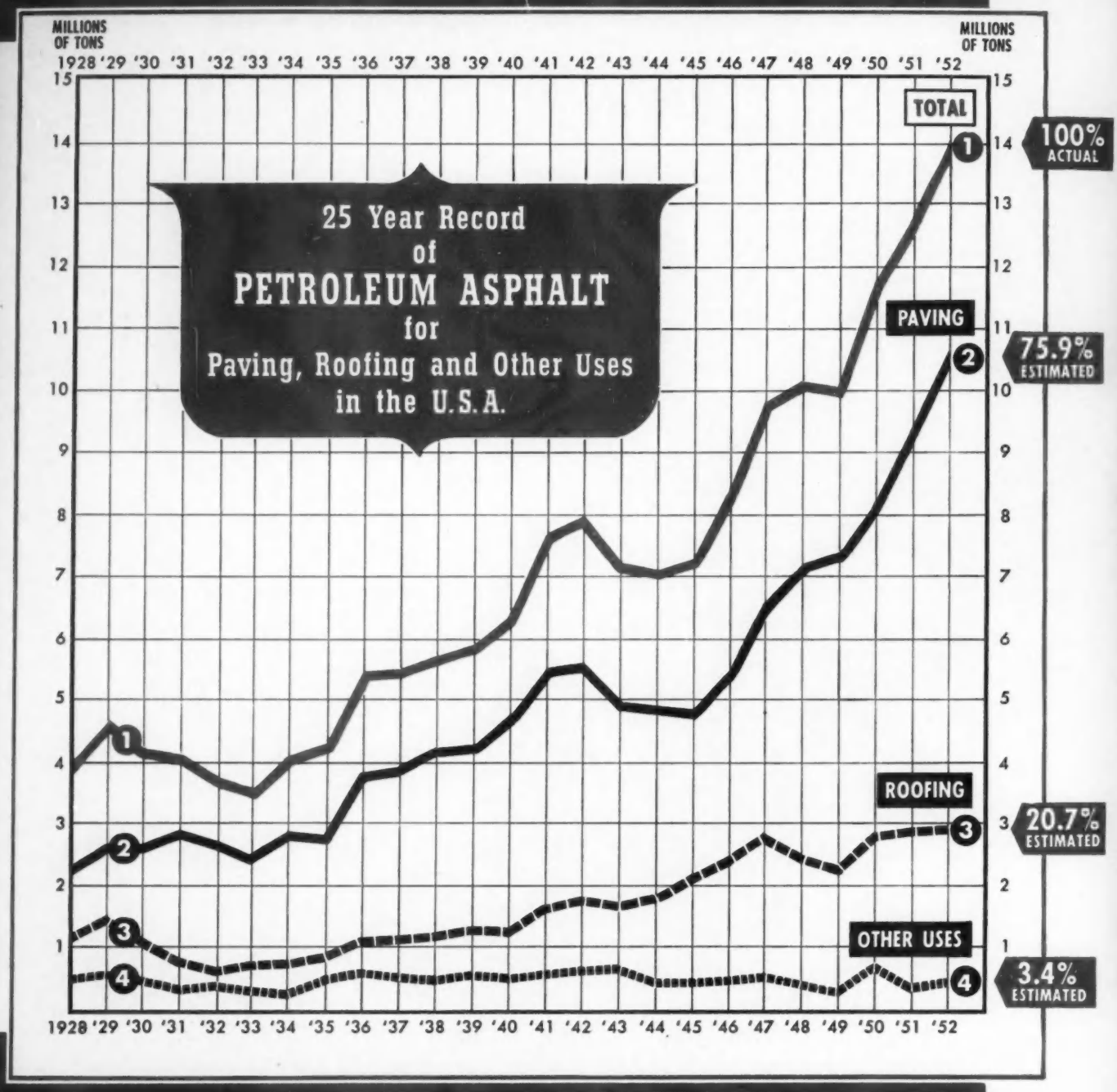
Asphalt Institute Quarterly

APRIL 1957




MILLIONS OF TONS
MILLIONS OF TONS
1928 '29 '30 '31 '32 '33 '34 '35 '36 '37 '38 '39 '40 '41 '42 '43 '44 '45 '46 '47 '48 '49 '50 '51 '52
25 Year Record
of
PETROLEUM ASPHALT
for
Paving, Roofing and Other Uses
in the U.S.A.
TOTAL
100% ACTUAL
PAVING
75.9% ESTIMATED
ROOFING
20.7% ESTIMATED
OTHER USES
3.4% ESTIMATED
KEY
1 TOTAL (=2+3+4)
2 PAVING
3 ROOFING
4 OTHER USES
SOURCE: U. S. BUREAU OF MINES ANNUAL FIGURES
CHARTED BY THE ASPHALT INSTITUTE APRIL 1953

ASPHALT INSTITUTE Quarterly

VOL. 5, No. 2 APRIL 1953

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The names of the Member Companies of the Institute, who have made possible the publication of this magazine, are listed herein on page 15.

EDITORS

Bernard E. Gray, *President of The Asphalt Institute*
Ernest M. Bristol, *Director of Public Relations*

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Articles may be freely reprinted with credit line. Correspondence should be addressed to the Asphalt Institute Quarterly, 801 Second Avenue, New York 17, N. Y.

COVERS

Featured on the covers is a tremendous Los Angeles housing project, where 530,000 square feet of asphalt roofing have just been used to protect *all the structures*. This shows a built-up asphalt roofing type, comprising five individual layers of asphalt-saturated roofing felt, each asphalt-coated, on which there was then applied a flood coat of pure asphalt and covering of gravel.

Photo credit: Spence Air Photos, Los Angeles

This twenty-five year Petroleum Asphalt chart illustrates the product's rapid, almost continuous growth. The past nine years show steady advances from approximately 7,000,000 to 14,000,000 tons annually, with Paving considerably more than doubled in the period. Roofing has reached approximately 3,000,000 tons annually.

EDITORIAL

Every so often throughout history materials are found which are of such outstanding usefulness that there seems to be no limit to their potential development. Man's progress over the centuries is measured by the advances made in this ability to discover and adapt new materials to current needs. Not until the discovery of copper, and its alloy with tin for making tools and weapons, did man take a real step forward from the long years of limited operations with crude stone implements. With the further discovery of iron and the subsequent making of steel, additional great steps ahead were made. The steel age is our present period, and the development of automobiles and trucks has required production of other essential materials, capable of providing coordinated facilities so that their full efficiency might be achieved. One of these materials is asphalt — a natural constituent of some petroleum.

Asphalt is not entirely a new product, for in limited degrees it has been in use from very ancient times. Thousands of years before the Christian era, wars were fought over this material to obtain access to its natural sources, such as the Dead Sea. These conflicts continued even to 1904, when international tensions were apparent over the "natural" asphalt deposits in South America.

Originally, asphalt was employed principally as a cement in masonry construction with sun-dried brick in the Middle East. Some of the structures so built still may be seen after the passage of thousands of years. Waterproofing, too, was a common use of this material, especially in an age when metal containers were scarce and where the coating of woven basketry or bound reeds was one of the methods of providing containers for fluids or for the making of boats.

All of the early sources of asphalt were available because an asphalt-base petroleum had escaped from underground to a depression in the surface, where in nature's refinery the lighter constituents evaporated leaving the asphalt cement behind. The famous Lake in Trinidad, the Bermudez Lake in Venezuela, and many others around the world were formed in exactly this same fashion. Sometimes with the squeeze and upheaval in the earth's crust these deposits were enfolded with sands and lime, making the so-called rock asphalts. The quantities thus available, while they were relatively small, sufficed for the limited needs of these early periods.

The rapid growth of motor vehicle production in the United States completely changed this picture. It is not too much to say that without *petroleum asphalt,* there would be no highway system as we know it today; for of all our miles of surfaced highways and streets, over 80% are built with asphalt. It is used also as a filler for brick and block pavements, for the joints in concrete, and as a repair material universally. To meet these modern needs, the recovery of asphalt directly from crude petroleum has reached very large proportions, rising for the year 1952 to three and a half billion gallons. The major portion of this huge volume (now over 75%) is employed for paving of highways, streets, airfields, parking lots, driveways, storage yards, and similar areas. In addition, however, there is the paving, literally, of the *roof-tops,* and the view on the covers, representative of similar locations all over the country, indicates the degree to which we are dependent in our modern civilization on this material. It is fortunate that asphalt is available in sufficient amount to meet our needs.

Oil Wells Produce the Crude

Refinery Operations Continue Around the Clock

ASPHALT AS A MATERIAL

(FIRST OF A SERIES)

By John M. Griffith

Engineer of Research, The Asphalt Institute

Asphalt is a black, cementitious material naturally present in most crude petroleum, from which it is separated by various processes which also yield gasoline, kerosene, lubricating oils and other valuable petroleum products.

WIDE RANGE OF CONSISTENCIES

As cream may be separated from milk in consistencies varying from light coffee cream to butter, so also may asphalts be separated from petroleum in varying consistencies. Refinery processes, such as blowing with air, dilution with light petroleum solvents or emulsifying with water provide a wide range of useful products varying in consistency at normal temperatures from hard solids to viscous liquids.

"NATURAL" ASPHALTS

Asphalts also occur naturally in pits or lakes. These asphalts are residues from crude oils which have seeped up through fissures and from which the lighter fractions have evaporated over many thousands of years. Such asphalt, however, constitutes only a small part of that used in the United States today due to the cost of transportation. U. S. Bureau of Mines figures for 1951 show that ". . . natural asphalt imports, chiefly from Trinidad . . ." totalled only 5,269 tons whereas petroleum asphalts for that year amounted to 12,832,900 tons.

RECOVERY AND REFINING

The Petroleum Flow Chart, Page 5, illustrates in a general manner the flow of crude petroleum through a refinery. This chart emphasizes that portion of the process related to the recovery and production of asphaltic materials. The crude oil first enters a tube still where it is heated. It is then delivered to the fractionating column where the lighter fractions are vaporized and drawn off, leaving a residual of heavy oils and asphalt. This residual may be used as a fuel oil or as a road oil.

Road oils are usually designated as liquid asphalts of the Slow Curing (SC) grades. They may vary widely in consistency depending upon the proportion of oils removed in the fractionating column. The SC-0 is the most liquid of the standard grades and is about the consistency of a heavy cream at room temperature. At the other end of the scale, SC-5 is the most viscous of these materials and at room temperatures is about the consistency of a heavy molasses in cold weather. Standard test procedures and specification limits describe more fully the properties of these materials and may be found in "The Asphalt Handbook" and "Useful Tables" published by The Asphalt Institute.

By far the largest proportion of residue, however, is processed into penetration grades of asphalt cement, some of which are still further processed into cut-backs and emulsified asphalts. It is well known that pressure cookers are used to increase the boiling temperature of liquids. Conversely, vacuum is used to decrease the boiling temperatures. A vacuum tower is used to process the residue at lower temperatures and produce penetration grades of asphalt.

The residue from the fractionating column may also be processed at elevated temperatures with air to produce blown or oxidized asphalts. Air is introduced near the bottom of the blowing still, causing a hardening of the residue and producing other desirable properties for roofing and specialized industrial applications.

In the production of asphalt the residue is fed into the vacuum tower, a vacuum applied, and the desired amount of oily fraction drawn off in vapor form. This process is continued at temperatures close to 500° F. until the desired consistency of asphaltic residue is reached. Steam is often introduced in this process as it aids in the distillation procedure.

Thus we obtain the vacuum reduced or steam and vacuum reduced asphalts of penetration grades.

Petroleum Serves the Motorist – Gasoline, Oil, and Asphalt in Use

trolled by the amount of solvent in the cut-back asphalt. Complete test and specification requirements for these materials are available in Asphalt Institute publications.

Emulsified asphalts are prepared in special, high-speed mixers wherein water is used as the dispersant rather than light petroleum fractions. The three usual grades of emulsions are: Rapid Setting (RS), Medium Setting (MS) and Slow Setting (SS). Emulsifiers in extremely small quantities are used which control the rate at which these products "break" or "set." They usually contain 30-45 per cent of water and may either be used at normal temperatures or warmed slightly to increase fluidity where desirable. The Asphalt Institute has specifications available which fully prescribe the test properties and specification limits of standard grades of emulsified asphalts as shown on the Chart.

Thus we may see that asphalt is not one specific product but rather *a family of products* covering a wide range of consistencies. The wide variety of these products carries with it the attribute of extreme versatility in use. Asphalts are predominantly the choice for all types of paving work, from the low-cost dust-laying operations, through the intermediate cold-mix pavement surfaces, and into the highest type of hot-mix asphaltic pavement surfaces. They are used for stabilizing soils and base materials, for surface treatments, and for strengthening and resurfacing old pavements by overlaying. They are also used in many types of roofing applications, in seepage and erosion control, and in a wide variety of commercial and industrial applications. It is definitely one of the *most versatile* of durable materials.

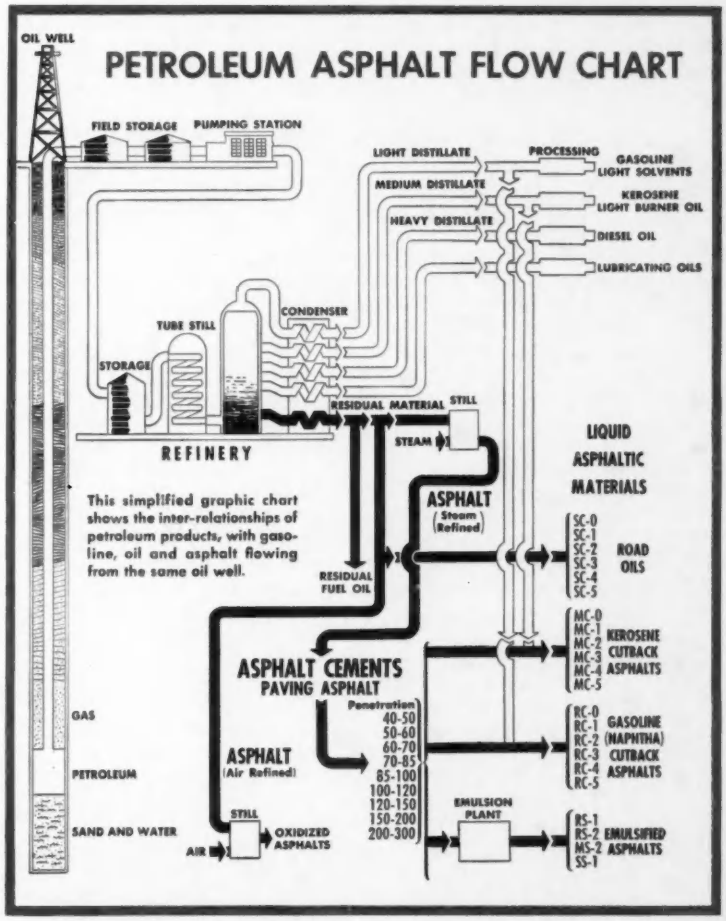
PENETRATION TEST MEASURES CONSISTENCY

The consistency of these asphalts is measured by the penetration test. A needle of standard dimensions, approximately the size of a sewing machine needle, is loaded with a standard weight. The weighted needle is allowed to bear for a given length of time on the surface of a dish of asphalt, with the asphalt being at a standard test temperature. The depth of penetration of the needle into the asphalt under these standardized conditions is termed the penetration of the asphalt and is measured in units of 1/10 millimeter. The needle penetrates more into soft asphalts than into the harder grades. Thus the lower the penetration, the harder the asphalt.

Penetration grades of asphalt are usually called asphalt cements and are produced over a range of consistencies. The standard grades are indicated on the Flow Chart at right. Other tests and specifications are usually prescribed for these materials and are more fully outlined in the Institute publications mentioned. The softest (200-300) penetration grade of these asphalt cements is only slightly harder than the SC-5 grade of liquid asphalt. The hardest (40-50) penetration grade normally produced is of a consistency such that only a slight thumb imprint may be made on the surface at room temperatures. Harder grades, however, are produced for special purposes. Penetration grades of asphalt must be liquified by heating for use in paving and other applications.

LIQUID ASPHALTIC MATERIALS

It is often desirable to have asphalts which are liquid at normal temperatures or which require only a moderate amount of heat for suitable fluidity. Cut-back asphalts and emulsified asphalts are prepared for this purpose. Cut-back asphalts are prepared by blending penetration grades of asphalt cement with light petroleum fractions such as naphtha and kerosene. Naphtha evaporates quickly at normal temperatures and is used for the Rapid Curing (RC) grades of cut-back asphalt. Kerosene evaporates more slowly than naphtha and is used for the Medium Curing (MC) grades of cut-back asphalts. The RC, MC and SC materials are all produced in a range of similar viscosities. Thus the RC-O and MC-O are the most fluid and of a comparable consistency to the SC-O. Likewise the RC-5 and MC-5 grades are comparable in consistency to the SC-5 grade. The consistency is con-



STRESS-CONDITIONING FLEXIBLE PAVEMENTS

by Bernard E. Gray

The Vibro Tamper settling base rock.

Paired Vibro Tampers speed construction operations.

Photos: International Vibration Co., Cleveland, Ohio

In an age of rapid technological development it is necessary to review continually the procedures under which engineering works are accomplished. This applies as much to pavements as to other structural designs, and from time to time suitable changes in specifications should be made to meet new conditions. Heavy modern traffic, with its ever increasing volume, imposes weights and frequencies of loadings far greater than those of even a mere decade ago. Because gradual conditioning of foundations over the years, a natural process in the twenties and thirties, is no longer possible, current techniques should provide *at once* the full measure of strength required.

This idea of stress-conditioning structures is not new, but it has come to the forefront in recent years to secure economy of materials. Economy, however, is not the only consideration. It is also necessary to build in such a way that the structure will be immediately equal to extreme loading conditions without necessity for later adjustments.

STRESS-CONDITIONING — YESTERDAY AND TODAY

How can a flexible pavement be stress-conditioned and how is it supposed to react? Forty years ago, when water-bound macadam was the standard surface for main highways, it was anticipated that traffic would provide additional consolidation until optimum density was secured. This did take place with very little differential settlement, because vehicles were slow and heavy and equipped with wide steel tires. As traffic ground off sufficient stone dust, and rain washed the particles downward, the pavement did become completely densified. Many of these older roads have attained such high strength values that now, having been resurfaced with a waterproof covering, they are able to carry modern traffic without any distortion.

In contrast, roads constructed today, even on new locations, may be immediately subjected to traffic volumes running as high as 100,000 vehicles per day, with a large proportion of trucks. That such traffic imposes more severe stress conditions and in more concentrated areas than in former years is perfectly apparent, particularly as multiple-lane highways tend to *channelize* traffic rather continuously with only minor lateral movement. This is in marked contrast with the pattern of traffic of several decades ago, when the road had a higher crown and traffic tended to move laterally over a much wider area. To meet these new conditions it is desirable to make a complete review of present construction specifications and provide for compaction procedures that will immediately produce *throughout the roadbed structure* the shear strength that formerly was developed after several years of gradually increasing traffic volumes.

Few changes of importance have taken place in specifications for granular base course construction in the past twenty-five years. The paragraph on compaction, from the specifications of a State doing excellent work, reads in part as follows:

> "Coarse aggregate shall be rolled with a three-wheel power roller weighing not less than ten (10) tons . . . The rolling shall continue until the surface is firm and even and does not creep or wave ahead of the roller . . . all of which will be done under the direction of the Engineer."

What is now needed, of course, is more precise definition in respect to the degree of consolidation required to meet specific conditions of use.

In subgrade treatment there has been perhaps somewhat greater improvement, due to the development of the science of soil mechanics. Yet even here specifications have not been revised in all cases to utilize completely the potential strengths found in readily available local materials. In every instance where appropriate controls have been used the increase in load support values from subgrade treatment alone has been remarkable. Recent projects such as the New Jersey and the Oklahoma Turnpikes are examples of what can be accomplished in economical construction through attention to this important item.

A rather extreme example of the effect of heavy loading in producing differential settlement, where all layers have not been stress-conditioned, is a recent test pavement where very heavy wheel loads were applied to a new flexible pavement consisting of a macadam base and an asphalt surface. On the subgrade, compacted in accordance with modern standard density requirements, a macadam base was placed approximately twenty-two inches thick. The asphalt surface was a hot-mix, placed to a depth of about three inches and consolidated to high density. Loading was provided by pneumatic-tired carryalls, *with concentrations of 50,000 and 60,000 pounds per wheel* and with extremely high tire pressures. After many hundreds of applications of these very heavy loads, a wide rut was formed in the pavement until a

settlement of three inches had occurred. A section cut through this rutted area indicated the effect of such loading. The results may seem surprising, yet they reflect the importance of adequate compaction for the anticipated loading conditions. There had been practically no settlement in the subgrade, but the macadam base had been *further consolidated* by nearly three inches, until it had become almost a solid rock. Although the asphalt surface had been depressed with the macadam base, there was no cracking at the edges and, particularly, little reduction in thickness. In other words the macadam base, which originally had appreciable voids despite consolidation to standard density, had been so well compacted by the test loading that its strength had been greatly increased.

This example emphasizes the desirability of subjecting pavements, during construction, to loads which are greater than the traffic loads subsequently to come upon them. Work in this direction, of course, is already under way, and heavy pneumatic rollers with 50,000-pound wheel loads, such as the Super-Compactor, have been employed in the construction of several highway projects and airfields. Such stress-conditioning searches out weak spots well below the surface that otherwise might be left even in the soil layers prior to placement of the subbase and base courses. Occasionally, such weak spots develop after grading has been completed, either because of faulty drainage or a previously undetected wet weather spring. With the use of heavy compaction equipment such soft spots have been discovered as much as six feet below the top of the subgrade, and needed adjustments were thus possible *before* placement of the upper foundation layers.

NEW COMPACTION EQUIPMENT

The point to emphasize here is that, in modern-day construction, rolling with only the standard ten-ton roller is no longer a complete compaction procedure for all phases of work. This does not mean that such rollers no longer will be employed. Actually, because of the great expansion in highway construction and maintenance, they will be needed in greater numbers than ever before. They will be efficient for all situations where the ten-ton weight of the rollers produces the density required. Such procedure is usually sufficient with the asphalt mixtures, because the particles will readjust themselves under such loading to produce the minimum voids required. In contrast, the high internal friction in granular bases usually requires additional procedures to produce necessary densities. Hence either a combination of vibration with rolling, or the use of much heavier weight rollers, is indicated. In some cases the asphalt layers resist compaction to the desired degree. Usually this is not large in percentage of voids, and rolling with pneumatic-tired rollers in combination with the steel-faced rollers will produce the desired standards.

THE ASPHALT SURFACE

Finally we must consider the function of the asphalt surface itself. As roads of various thickness combinations are studied, it becomes increasingly evident that the major portion of the flexible pavement structure can be secured through use of aggregates that require little or no binder other than the fines present in the materials themselves. With appropriate consolidation of such mineral aggregate layers, the asphalt surface need only be sufficiently thick to provide waterproofing and resistance to abrasion. This thickness requirement is analyzed in two catagories in the very excellent paper by Dr. Norman McLeod entitled "Tire Design, Pavement Design, and Vehicle Mobility," presented before the Highway Research Board in January, 1952. He describes, first, the relationship between the tire and the pavement surface and, second, the relationship between the surface course and the top layer of the foundation.

In regard to the first item, it is suggested that the efficiency of tires could be markedly improved if they had compartments with varying pressures so that a uniform unit pressure over the entire interface of the tire would be secured. Undoubtedly this would have a marked effect on pavement construction in reducing the thickness required to take the higher intensity loadings of the modern conventional-type tire. The larger savings, however, doubtless would come from longer-lived tires, by reason of equalized unit loading.

For the asphalt pavement itself even with present-day tires a wearing course of 2½ to 3½ inches is probably the maximum thickness required to resist the very heaviest loading where suitable base course aggregates are available. Such thickness will not only take care of the vertical loading but also will be resistant to movement in either longitudinal or transverse direction. Such a course, however, should be thoroughly bonded to the upper layer of the foundation. Although there are several alternate methods, depending upon kinds of aggregate available, this transition layer should be of a material having adequate shear strength and treated so that the surface course is thoroughly bonded to it. A penetration macadam base is probably one of the most satisfactory combinations with an asphalt plant-mix surface. The bond between the two is complete, and the heavier application of asphalt on the macadam aggregate base provides the waterproofing desirable for maximum durability. Where macadam is not available, this upper base course often can be provided either with sand-asphalt mixtures or gravel-sand mixtures of suitable stability for the stresses transmitted to them. There are also many local materials, such as limerock, shale, and chert, which are of adequate shear strength. When these are used, however, the surface should first be adequately primed so that the same complete interfacial bond is provided.

The intention of this review is to emphasize principally one point — namely, that each layer in the composite pavement structure shall receive such degree of compactive effort that under traffic stress it will not be subject to further settlement by consolidation. Conventional equipment long in use, such as ten-ton rollers, will accomplish the desired objective with some materials but not with others. To insure desired controls, however, it is necessary merely to include the newer available equipment such as heavy-wheel compactors, pneumatic-type rollers, and vibrators. By so doing, the completed pavement will be stress-conditioned for maximum loading.

Left: 100,000-pound Supercompactor stress-conditions flexible pavements to desired standards.
Photo: American Supercompactor Corp.

Right: 400,000-pound roller used on heavy-duty air bases and superhighways.
Photo: Shovel Supply Co.

Inexpensive remodeling and re-roofing with asphalt shingles have restored the dignity and charm of this pre-Civil War house.

ASPHALT IN ROOFING

Roofing was probably the world's first craft, for shelter has always been one of the primary material needs of man. From the beginning, he has had to protect himself against the relentless forces of nature: from extreme heat and cold, from rain, wind, hail, snow and ice.

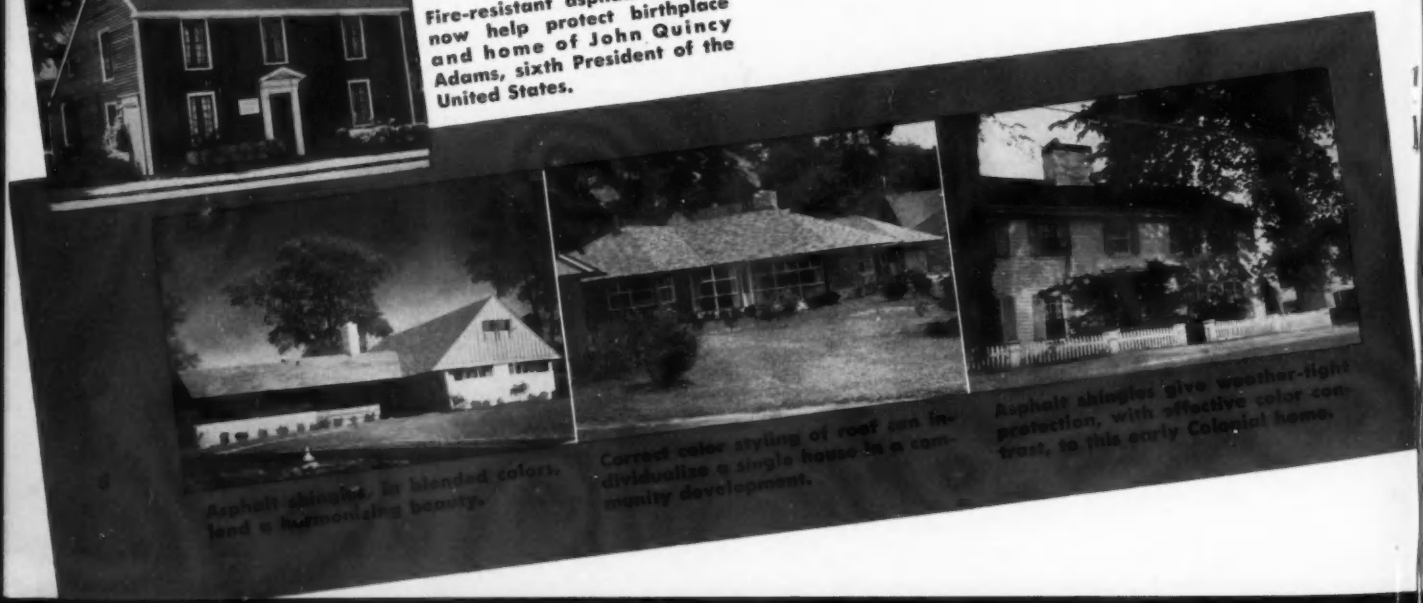
Asphalt, with its extraordinary combination of waterproofing, preservative and cementing qualities, was an early discovery of ancient peoples. They used it extensively in the construction of their buildings and roads, many of which, after thousands of years of exposure to the elements, are still existing, well preserved. Asphalt waterproofed Noah's Ark; it embalmed Egyptian kings.

The modern builder understands that asphalt produces most efficient "paving" both for roads and roofs. In the construction of asphalt roads, it so adheres and binds that it stands up for many years, improving with age, under heaviest traffic. In roofing, another form of "paving," the same lasting, essential qualities have been proved.

In terms of public acceptance, the Department of Commerce figures show that 85 to 90 percent of the entire *annual* roofing coverage in the United States is now asphalt roofing. This predominance is being reflected in steady, substantial, yearly growth in asphalt tonnage for roofing. In 1940 this was less than a million and a half tons; in 1952 it had more than doubled with approximately three million tons.

On the farm, in renovating this old barn, a vital part of the improvement was its reroofing with asphalt shingles.

Fire-resistant asphalt shingles now help protect birthplace and home of John Quincy Adams, sixth President of the United States.



Asphalt shingles, in blended colors, lend a harmonizing beauty.

Correct color styling of roof can individualize a single house in a community development.

Asphalt shingles give weather-tight protection, with effective color contrast, to this early Colonial home.

Municipal Airport, Kansas City, Kansas — asphalt base and gravel top roof, applied in 1930.

Photo: Old American Roofing Mills, KansasCity, Mo.

Photo, by courtesy of Hydraulic Press Manufacturing Co., shows asphalt built-up roofing on their plant at Mount Gilead, Ohio.

ASPHALT MEETS ALL REQUIREMENTS

Asphalt comes from petroleum so refined as to produce the types best suited to roofing requirements. It is quite remarkable how many changes refining can achieve. For example, refining can make asphalt hard or soft, pliable or brittle, thick or thin. It can also be refined so it will melt at a relatively low or at a much higher temperature.

The important fact to remember is this — a roofing manufacturer can select the asphalt refined correctly to standards that will make roofing of uniformly high quality, best suited to his requirements.

ASPHALT ROOFING TYPES

1. *Asphalt shingles* are composed of three basic materials — asphalt, felt, and mineral granules. The felt is impregnated with an asphalt saturant. Both sides of the saturated felt are then covered with a harder, tougher coat of asphalt, in which are embedded mineral granules. This composition is then cut into individual shingles or strips.
2. *Asphalt roll roofing — smooth surfaced.* This type is made up of a single layer of roofing felt saturated with asphalt and coated on both sides with a harder asphalt.
3. *Asphalt roll roofing — mineral surfaced.* This type consists of smooth surfaced roll roofing in which mineral granules have been embedded on either one or both sides.
4. *Asphalt built-up roofing.* An asphalt built-up roof is composed of several layers of asphalt-saturated felt applied to a flat or slightly sloped roof-deck. Between the felt layers, for adhesion, a liquid asphalt is first applied. Over the top layer a flood coat of asphalt is then added and this is covered with gravel or slag.

Continued on page 10

This high school gymnasium in Miami, Florida, is protected by an asphalt roof installed in 1937.

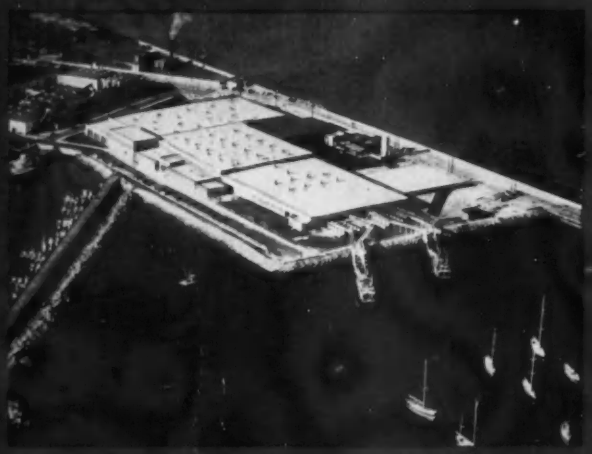
Photo: Bird & Son, Inc., East Walpole, Mass.

California Packing Corporation's long-lasting asphalt roof at San Jose.

Photo: Pabco Products, Inc., San Francisco.

The roofs of the mammoth Stonestown shopping development in San Francisco are "paved" with asphalt.

Heavy-duty asphalt roof, designed to give trouble-free service, applied to Lever Bros. plant, Los Angeles.



The new Star-Kist Tuna factory in Wilmington, California, boasts a fine, new asphalt roof.

Photo: Bonner Division, Flintkote Co., San Francisco

Continued from page 9

Of the types listed on the preceding page, the shingle roof has been the most common. Asphalt shingles are applied to the steep roofs of homes, barns and similar structures. They fill the need for an attractive, efficient, and fire-resistant but low-cost roofing for residential construction.

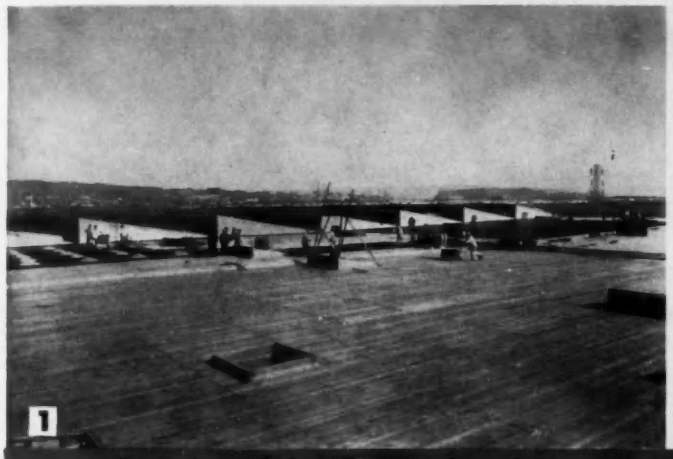
The built-up roof is a contrasting type, constructed on the flat or nearly flat tops of very large buildings—industrial, public and many others. These roofs are literally "paved" with asphalt, although in a manner quite different from the paving of roads.

CONSTRUCTION PROCEDURES

Asphalt built-up roofing consists of a number of layers of asphalt-impregnated felt laid over flat roof decks. In the most common method of construction, hot liquid asphalt is mopped over each layer of felt, and over the top ply a final coating of asphalt is applied This in turn is covered with slag or gravel to lengthen life by affording protection from the heat of the sun and prevailing climatic elements.

Methods of application and types of asphaltic materials used vary according to specifications. Often built-up roofs are of the cold-process type, which calls for a final coating of asphalt, applied by brush or spray, instead of the slag or gravel. Yet whatever the method and type of asphalt, its use insures economy. Asphalt felts, manufactured at low cost and put up in rolls of a convenient size, are easily transported. Since they are flexible and pliable — and thus conveniently handled —their application to the roof deck is simple and does not require highly-skilled labor.

The mopping on of the liquid asphalt and the spreading of slag or gravel may be accomplished with the most readily available and simplest type of equipment. All operations can be performed quickly by the hand method of application, although for very large roofs mechanical felt-laying machines, hot-asphalt applicators, and gravel spreaders have been developed which will do the job more easily and rapidly. If properly constructed an asphalt built-up roof will remain in top service condition for many years with usually little or no maintenance required. If it is found that occasional patching is necessary, it can be done at negligible cost.



Beginning of installation of asphalt built-up roof on new Crown Zellerbach Converting Plant, San Leandro, California.

Pumping hot asphalt from ground level to roof deck.

The other principle type of asphalt roofing is the shingle. Here again asphalt-impregnated felt is employed, but in addition this felt is covered on both sides with a surface coat of asphalt in which mineral granules are embedded. Then the felt is cut into individual shingles, or into strips of shingles, which are nailed to the roof.

Asphalt shingles are designed for beauty as well as strength. The application of mineral granules in various patterns and colors afford the buyer the opportunity to choose the shingle which will best fit his home. The heavy-duty asphalt coating insures maximum durability and long life, while the mineral granules, in addition to providing beauty and color, afford further protection to the other basic materials comprising the shingle.

OUTSTANDING ADVANTAGES

Why has asphalt attained such a position of dominance in the roofing field? There are numerous reasons. The most important is that asphalt roofs fulfill the primary requirements of durability and long life. Building owners naturally ask for a roof which they can be sure will last for many years with only a minimum amount of maintenance required. Most of them choose asphalt roofing because they can depend on it. The asphalt roofs on many of the buildings pictured here have a service life of well over twenty years, and there are thousands like them.

Long life and durability stem from the special characteristics of asphalt. Asphalt roofs are waterproof as well as fire-resistant, and are less subject to temperature change than other types. Because asphalt can be processed so that it will have a high melting-point, it does not melt and flow in excessively hot weather. In the other extreme, asphalt can be processed to resist the effects of very low temperatures. Thus roofs constructed of asphaltic materials perform well in all climates and in all kinds of weather — which explains their predominant use throughout the United States.

END

Mechanized laying machines apply the asphalt-impregnated felt.

Aerial view of Crown Zellerbach plant showing completed asphalt roof, covering an area of 300,000 square feet.

Photos: Pabco Products, Inc. San Francisco.

1 Breaking old portland cement concrete pavement prior to removal.

2 Defective slab removed before replacement with asphaltic concrete.

PATCHING AND SLAB REPLACEMENTS of Portland Cement Concrete Pavement

By Walter F. Winters
Chief Engineer, The Asphalt Institute

In the course of the past twenty years many thousands of miles of the surfaced highways of the country have been constructed of portland cement concrete. Today heavy trucking and high-volume traffic have so worn these surfaces that most highway departments find that a quick economic method of repair is a pressing need.

Patching with portland cement concrete has been done in some areas, but the cost has been high and the barricading of portions of the road under maintenance has created a traffic hazard which slows down vehicle movement and is a frequent cause of accidents. In many parts of the country there has been a very unfavorable public reaction to this potential danger and newspaper headlines referring to the "Highway Barricades" have spearheaded safety campaigns to eliminate them.

The difficulties imposed by concrete patching of old cement highways—both the disruption of traffic and the high cost of the work—have led to the development of asphalt patching types for use wherever complete asphalt resurfacing may not yet be required.

REPLACEMENT TYPES OF PATCHING

In general, heavy maintenance patching with asphalt can be divided into two types:

1. Surface patching (also called overlay patching or spot resurfacing)
2. Full depth slab replacement (sometimes called inlay patching)

Thorough patching is warranted where defects due to surface or base failures have developed, even though a substantial part of the original pavement may be in good condition. Failure of portions of a pavement may be due to subgrade inadequacies or changed traffic conditions. Before replacement or rehabilitation of these portions the engineer should make a thorough investigation to determine what areas need repair, what caused the failures and how they can be corrected.

Surface patching, using asphaltic concrete overlay on worn portland cement concrete.

SURFACE PATCHING

Highway engineers use the surface-patching method to correct vertical alignment and improve the riding surface. Applied to pavements where the concrete joints are out of line, this type of patch reduces impact loads and, if thick enough, adds materially to the original loading values of the cement concrete pavement. The size of the patch may vary from a few square yards to areas several hundred feet

3 Placing and compacting asphaltic concrete patching.

4 Finishing the inlay patch by edging and rolling.

in length depending on the condition of the pavement and the extent of the failure.

It is seldom good policy to use the surface-patching method where the concrete slabs are badly cracked, because this type of patch is relatively thin and any vertical movement of the slab beneath it will quickly cause a cracking and spalling of the patching material. It is usually advisable to stabilize such slabs with asphalt underseal or to replace them entirely. For patching, a small aggregate mix is usually required since feather-edging is needed to prevent bumps. A great deal of spot resurfacing has been done using a three-inch lift of asphaltic concrete placed over portions of old pavements which have failed, and this thickness is "run-off" in about thirty feet on each side of the patch.

There are many different methods of surface patching in which various mixes are employed. Cold mixes of cut-backs or emulsions are sometimes used, and many roads are patched by the penetration method. Hot-mix asphaltic concrete, however, makes the best surface patch. Before application it is first necessary to clean the area to be patched and then prime it with a light cut-back or emulsion. Care should be taken to use a minimum amount of priming material to avoid flushing through the asphaltic patch. If the patch has some depth, it may be advisable to use a binder course of asphaltic concrete and to finish with a fine surface mix. Each patch should be laid in lifts of not more than two or three inches and each course thoroughly compacted before the second course is placed. Surface patching, if carefully constructed in proper location, will perform satisfactorily and afford a very efficient means for the repair of old portland cement concrete highways.

FULL DEPTH SLAB REPLACEMENT

The full-thickness patch is generally used where the area of failure is relatively small; where corrective subgrade treatment is essential; or where the broken slabs rock under traffic and cannot be satisfactorily stabilized. The first step in constructing this type of patch is to break and remove the failed concrete. Several methods may be used in the slab replacement. The new slab, for example, may be constructed entirely of an asphalt mixture, or else with an aggregate base and an asphalt topping. If the latter method is used with an open-graded aggregate base on a soft clay foundation soil, a layer of several inches of fine aggregate, preferably crushed stone or slag screenings, should be spread on the subgrade before the base course aggregate is placed. This prevents the saturated clay soil from being forced up into the coarse aggregate and weakening the base structure. The topping on this type of asphalt patch should be not less than three inches thick.

The most common slab-replacement patch incorporates the use of asphaltic hot-mix for the full depth of the concrete slab. In this type of patch, the subgrade is prepared and compacted at the proper depth after the concrete has been removed. Inadequate sub-bases are replaced with granular material and poor drainage is corrected. In either type of slab-replacement patch it is essential that all areas be adequately compacted with rollers, air hammers or vibrating tampers in order to avoid future settlement. It cannot be too strongly emphasized that the success of this type of patching depends on proper compaction of the entire patch.

In the full-depth asphalt patch, after the subgrade has been properly prepared, the exposed vertical edges of the concrete are first given a coat of asphalt priming material, followed by the application of a sufficient amount of hot asphaltic mix to form a layer not more than four inches in thickness. It may be advisable to place the hot-mix in layers not more than two or three inches thick to allow much of the heat of the mix to dissipate before placing the next lift. Each layer is compacted with rollers or mechanical tampers and finished to a point about ¼-inch below the concrete surface. If sufficient heat has been dissipated in laying the separate lifts, it may be advisable to finish the last course flush with the concrete surface.

Greater densities will be obtained in the replacement patch if it is subjected to traffic for several days before the final surfacing. The ¼-inch space between the depressed patch and pavement surface is a depth sufficient for the placement of a final surface course after traffic has provided suitable compaction. Expected traffic conditions should always be a first consideration, however, as experience has proven that heavy trucks will tend to crack the adjacent concrete when as little as ¼-inch has been left for the finished course. Standard highway mixes can be used to good advantage when constructing the full slab depth asphaltic patch. The patched road may be opened to traffic as soon as the maintenance operation has been completed.

These two types of asphalt patching—spot resurfacing (overlay) and slab replacement (inlay)—definitely accomplish the main objective of eliminating the inconvenience and hazards of mile after mile of one-way traffic and barricades. It is possible that the former may have the more general use, but there are many conditions which can only be corrected by full depth slab replacement.

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Win L. Hindermann, with office at 854 Builders Exchange Building in Minneapolis, Minnesota, is District Engineer of the Asphalt Institute in the Midwest district, which consists of Minnesota, Iowa, North and South Dakota.

An engineering graduate of the University of Minnesota, where he received both a Bachelor of Science degree and Master of Science in Civil Engineering, he served for twenty-two years with the Minnesota Highway Department, both in the laboratory and in the field. He was Bituminous Engineer prior to his assignment as District Maintenance Engineer at Duluth, Minnesota, leaving this position in 1951 to join the Asphalt Institute.

Mr. Hindermann holds the rank of Lieutenant Commander in the United States Naval Reserve, having served in Washington, D. C. and the Pacific during World War II. He is currently President of the Minnesota Society of Professional Engineers; and his other technical membership affiliations include the American Society of Civil Engineers, Asphalt Pavement Technologists, American Road Builders Association, Highway Research Board and Sigma Xi.

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James C. Johnson, with office at 438 Hightower Building in Oklahoma City, joined the Institute Staff in 1951 and serves as District Engineer for the State of Oklahoma.

Mr. Johnson holds a B. S. degree in Mechanical Engineering with a M. S. degree in Civil Engineering from Oklahoma A & M. College. During his three and a half years in the Materials Testing Laboratory of the Oklahoma Highway Department, of which the last three were in the capacity of Assistant Soils Engineer, Mr. Johnson was the Highway Department representative on a Cooperative Research Project making extended soil-asphalt stabilization studies.

Serving four years during World War II in an Army Engineer Construction Battalion in Canada, Alaska, France, and Okinawa, Mr. Johnson is now a member of the Retired Reserve. His association memberships include the Association of Asphalt Paving Technologists; the American Road Builders Association; the Highway Research Board; the American Society of Civil Engineers; the Engineers Club of Oklahoma City; and the Oklahoma Society of Professional Engineers.

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